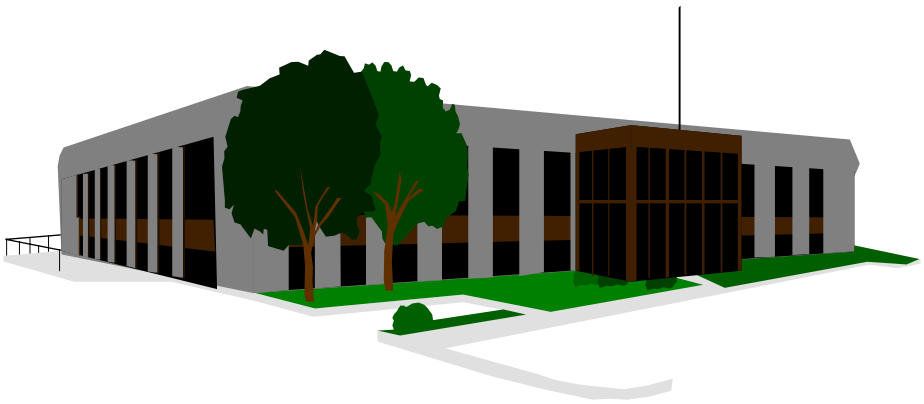
INDOOR AIR QUALITY ASSESSMENT

Archie T. Morrison Elementary School
15 Mayflower Road
Braintree, Massachusetts



Prepared by:
Massachusetts Department of Public Health
Bureau of Environmental Health Assessment
February, 2001

Background/Introduction

At the request of a parent, the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health Assessment (BEHA) provided assistance and consultation regarding indoor air quality concerns at the Morrison Elementary School, Braintree, MA. On November 22, 2000, a visit was made to the school by Cory Holmes, Environmental Analyst for BEHA's Emergency Response/Indoor Air Quality (ER/IAQ) program, to conduct an assessment. Mr. Holmes was accompanied by Gregg Donovan, Senior Custodian for portions of the assessment.

The school is a multi-level brick/cement slab building constructed in 1968. The rubber membrane roof was replaced in 1992. The school contains general classrooms, music room, media center, gymnasium, kitchen/cafeteria, computer room, several specialty rooms and offices.

The Braintree School Department has instituted a maintenance plan in which univents are serviced three times per school year; service includes changing of filters, oiling of motors and bearings, and vacuuming of unit interior. Maintenance log labels are attached to each unit and signed off by maintenance staff. Copies of the maintenance log labels are included as an attachment.

Methods

Air tests for carbon dioxide, temperature and relative humidity were taken with the TSI, Q-Trak, IAQ Monitor, Model 8551.

Results

The school houses first through fifth grade students with a population of approximately 340 and a staff of approximately 45. The tests were taken during normal operations at the school. Test results appear in Tables 1-4.

Discussion

Ventilation

It can be seen from the tables that carbon dioxide levels were elevated above 800 parts per million parts of air (ppm) in twenty of twenty-nine areas surveyed, which indicates inadequate air exchange in a number of areas in the school. Fresh air in classrooms is supplied by a unit ventilator (univent) system (see Picture 1). Univents draw air from outdoors through a fresh air intake located on the exterior walls of the building (see Picture 2) and return air through an air intake located at the base of each unit (see Figure 1). Fresh air and return air are mixed, filtered, heated and provided to classrooms through a fresh air diffuser located in the top of the unit. All univents were operable. However, univents appeared to be original equipment, which would make them approximately thirty-two years old.

Several univents were deactivated. The univent in classroom 202 was deactivated due to noise from the radiator system, which may indicate a leak in the system. Obstructions to airflow, such as items placed in front of univent returns, were seen in a few classrooms. To function as designed, univents and univent returns must remain free of obstructions. Importantly, these units must be activated and allowed to operate during hours of school occupation.

The computer room and library ventilation is provided by an air-handling unit (AHU) located in an adjacent mechanical room (see Picture 3). Supply air to each area is distributed via ceiling mounted air diffusers. Return air is drawn into ceiling-mounted exhaust grilles ducted back to the AHU (see Picture 4). It could not be determined if a fresh air intake exists for this AHU.

Ventilation for the gymnasium was originally provided by two ceiling-mounted AHUs which drew air from outdoors through fresh air intakes located on the exterior walls of the building (see Picture 5). These units were not operating during the assessment, and it could not be confirmed by school officials as to whether these units were still functional.

Elevated carbon dioxide levels were measured in the cafeteria during lunch. Supply ventilation is provided by wall mounted diffusers located near the ceiling. A large local exhaust fan was retrofitted in the cafeteria to provide mechanical exhaust ventilation. School staff reported that this fan was deactivated due to noise. In addition, the fan is in close proximity to the supply vent (see Picture 6) which can draw in heated fresh air and exhaust it directly outdoors preventing fresh air from mixing (this phenomenon is known as "short-circuiting").

The mechanical exhaust ventilation system in classrooms consists of grated, wall-mounted exhaust vents (see Picture 7), a number of which were drawing weakly (see Tables). Exhaust vents from individual classrooms are drawn into a common duct above the ceiling in the hallway to be expelled from the building via rooftop motors (see Picture 8). A number of exhaust vents were obstructed by tables, chairs, boxes and other items (see Picture 9). The location of exhaust vents can also limit exhaust efficiency when the

classroom hallway door is open. When a classroom door is open, exhaust vents will tend to draw air from both the hallway and the classroom. The open hallway door reduces the effectiveness of the exhaust vent to remove common environmental pollutants from classrooms. Without removal by the exhaust ventilation, normally occurring environmental pollutants can build up and lead to indoor air complaints.

To maximize air exchange, the BEHA recommends that both supply and exhaust ventilation operate continuously during periods of school occupancy. In order to have proper ventilation with a mechanical supply and exhaust system, the systems must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. The date of the last balancing of these systems was not available at the time of the assessment.

The Massachusetts Building Code requires a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or have openable windows in each room (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens, a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health

Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week, based on a time-weighted average (OSHA, 1997).

The Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches.

Temperature measurements ranged from 69^{o} F to 80^{o} F, which was close to the BEHA comfort guidelines. The BEHA recommends that indoor air temperatures be maintained in a range of 70 ^{o} F to 78 ^{o} F in order to provide for the comfort of building occupants. Temperature control complaints in classroom 201 were expressed to BEHA staff during the assessment, which may indicate problems with the univent pneumatic control system or that the thermostat is out of calibration. Heat complaints were reported in the computer room, which contained over 25 computers and a number of printers. Computer equipment and printers can generate excess heat while they operate, particularly if used frequently. As previously mentioned, it could not be determined if the AHU for this area was ducted to the outdoors. Without exhaust ventilation, waste heat can build up resulting in increased comfort complaints. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply.

The relative humidity measured in the building ranged from 29 to 39 percent, which was below the BEHA recommended comfort range. The BEHA recommends a comfort range of 40-60 percent for indoor air relative humidity. Relative humidity levels in the building would be expected to drop during the winter months due to heating. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

A number of rooms had water-stained ceiling tiles, which are evidence of either historic roof or plumbing leaks. Water-damaged tiles can provide a medium for mold and mildew growth and should be replaced after a water leak is discovered. Classroom 103 contained a number of stained ceiling tiles along the exterior wall above the windows. School staff reported that this leak had been repaired.

Several classrooms contained plants. Plant soil, standing water and drip pans can be potential sources of mold growth. Drip pans should be inspected periodically for mold growth and over watering should be avoided. Plants should also be located away from univents to prevent the aerosolization of dirt, pollen or mold.

Spaces between the sink countertop and backsplash were noted in several classrooms. Improper drainage or overflow could lead to water penetration of countertop wood, the cabinet interior and behind cabinets. Like other porous materials, if these materials become wet repeatedly they can provide a medium for mold growth, which is difficult to clean and can be irritating to sensitive individuals.

Classroom 207 contained a number of aquariums, terrariums and habitats housing snakes, frogs, fish, turtles and live crickets. School staff should ensure that aquariums, terrariums and other habitats are properly maintained to avoid bacterial and microbial growth.

Other Concerns

A variety of other conditions were noted during the assessment, which can affect indoor air quality. Classroom 109 contained a portable air purifier. These units are normally equipped with a filter, which should be cleaned or changed as per the manufacturer's instructions to avoid the build up and re-aerosolization of dirt, dust and particulate matter.

Accumulated chalk dust was noted in some classrooms. Chalk dust is a fine particulate, which can be easily aerosolized and serve as an eye and respiratory irritant. Several classrooms contained dry erase boards and dry erase board markers. Materials such as dry erase markers and dry erase board cleaners may contain volatile organic compounds (VOCs), (e.g. methyl isobutyl ketone, n-butyl acetate and butyl-cellusolve) (Sanford, 1999), which can also be irritating to the eyes, nose and throat.

A hamster was noted in classroom 108 and as previously mentioned classroom 207 contained various species of wildlife as well as a number of "stuffed" (taxidermy) animals. Animal dander, fur and wastes can all be sources of respiratory irritants. This environment can also provide a source of allergenic material (e.g. skin cells, insect body parts) to sensitive individuals. In addition to proper maintenance, animal cages should be

kept away from the air stream of ventilation components to avoid the aerosolization of allergenic materials and/or odors.

Filters in univents and AHUs were spot-checked and were equipped with filters that strain particulates from airflow. These filters provide filtration of respirable dusts. In order to decrease aerosolized particulates, disposable filters with an increased dust spot efficiency can be installed in the univents. School officials reported that efforts have been made to improve filtration in school univents. The dust spot efficiency is the ability of a filter to remove particulates of a certain diameter from air passing through the filter. Filters that have been determined by ASHRAE to meet its standard for a dust spot efficiency of a minimum of 40 percent (Minimum Efficiency Reporting Value equal to 9) would be sufficient to reduce many airborne particulates (Thornburg, D., 2000; MEHRC, 1997; ASHRAE, 1992). Note that increasing filtration can reduce airflow (called pressure drop) which can reduce the efficiency of the univent due to increased resistance. Prior to any increase of filtration, each piece of HVAC equipment should be evaluated by a ventilation engineer to ascertain whether it can maintain function with more efficient filters.

Cleaning products were found on counter tops and underneath sinks in a number of classrooms (see Picture 10). Cleaning products contain chemicals (such as bleach or ammonia-related compounds), which can be irritating to the eyes, nose and throat. These items should be stored properly and out of the reach of students.

Conclusions/Recommendations

In view of the findings at the time of this assessment, the following recommendations are made:

1. Continue with preventive maintenance plan for HVAC equipment. Check fresh air intakes for repair, an increase of the percentage of fresh air intake may be necessary. Consider consulting a heating, ventilation and air conditioning (HVAC) engineer concerning the calibration of univent fresh air control dampers school-wide.
2. Consult with an HVAC engineer as to whether exhaust ventilation for classrooms can be increased.
3. Determine if the AHU supplying the computer room and library is provided with outside air. If not, consider ducting to the outside to provide fresh air.
4. Inspect univent system in classroom 202 for leaks, and make repairs as necessary. Examine the area around leaks for water damage. Examine all univents periodically for similar leaks. Disinfect areas of water leaks with an appropriate antimicrobial if necessary.
5. Operate exhaust ventilation in cafeteria during lunch hours to circulate air, and to remove excess heat and odors. Consider installing a variable speed control to adjust fan speed (see Picture 11 for an example). Reconfiguration of cafeteria HVAC system may be necessary to avoid short-circuiting.
6. Examine AHUs in the gymnasium and operate if functional. If not functional, examine the feasibility of repairing/replacing units to provide fresh outside air.

7. To maximize air exchange, the BEHA recommends that both supply and exhaust ventilation operate continuously during periods of school occupancy independent of classroom thermostat control. Consider having the ventilation system balanced by a ventilation engineer.
8. Remove all blockages from univents and exhaust vents to ensure adequate airflow. Close classroom hallway doors to maximize exhaust ventilation.
9. Repair and/or replace thermostats and pneumatic controls as necessary to maintain control of thermal comfort.
10. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control for dusts, a high efficiency particulate arrestance (HEPA) filter equipped vacuum cleaner in conjunction with wet wiping of all surfaces is recommended. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).
11. Repair any roof leaks and replace any remaining water-stained ceiling tiles. Examine area above these tiles for mold growth. Disinfect areas of water leaks with an appropriate antimicrobial as necessary.
12. Ensure plants have drip pans, examine drip pans for mold growth and disinfect areas with an appropriate antimicrobial where necessary. Keep plants away from univents in classrooms.

13. Seal areas around sink in classrooms, to prevent water-damage to the interior of cabinets and adjacent wallboard. Inspect wallboard for water-damage and mold/mildew growth. Repair/replace as necessary. Disinfect areas of microbial growth with an appropriate antimicrobial as needed.

14. Clean chalkboards and trays regularly to prevent the build-up of excessive chalk dust.

15. Change filters in portable air purifiers as per the manufacturer's instructions to prevent the re-aerosolization of dirt, dust and particulate matter.

16. Store cleaning products and chemicals properly and keep out of reach of students.

References

ASHRAE. 1992. Gravimetric and Dust-Spot Procedures for Testing Air-Cleaning Devices Used in General Ventilation for Removing Particulate Matter. American Society of Heating, Refrigeration and Air Conditioning Engineers. ANSI/ASHRAE 52.1-1992.

BOCA. , 1993. The BOCA National Mechanical Code/1993. 8th ed. Building Officials and Code Administrators International, Inc., Country Club Hill, IL. Section M-308.1.1.

MEHRC. 1997. Indoor Air Quality for HVAC Operators & Contractors Workbook. MidAtlantic Environmental Hygiene Resource Center, Philadelphia, PA.

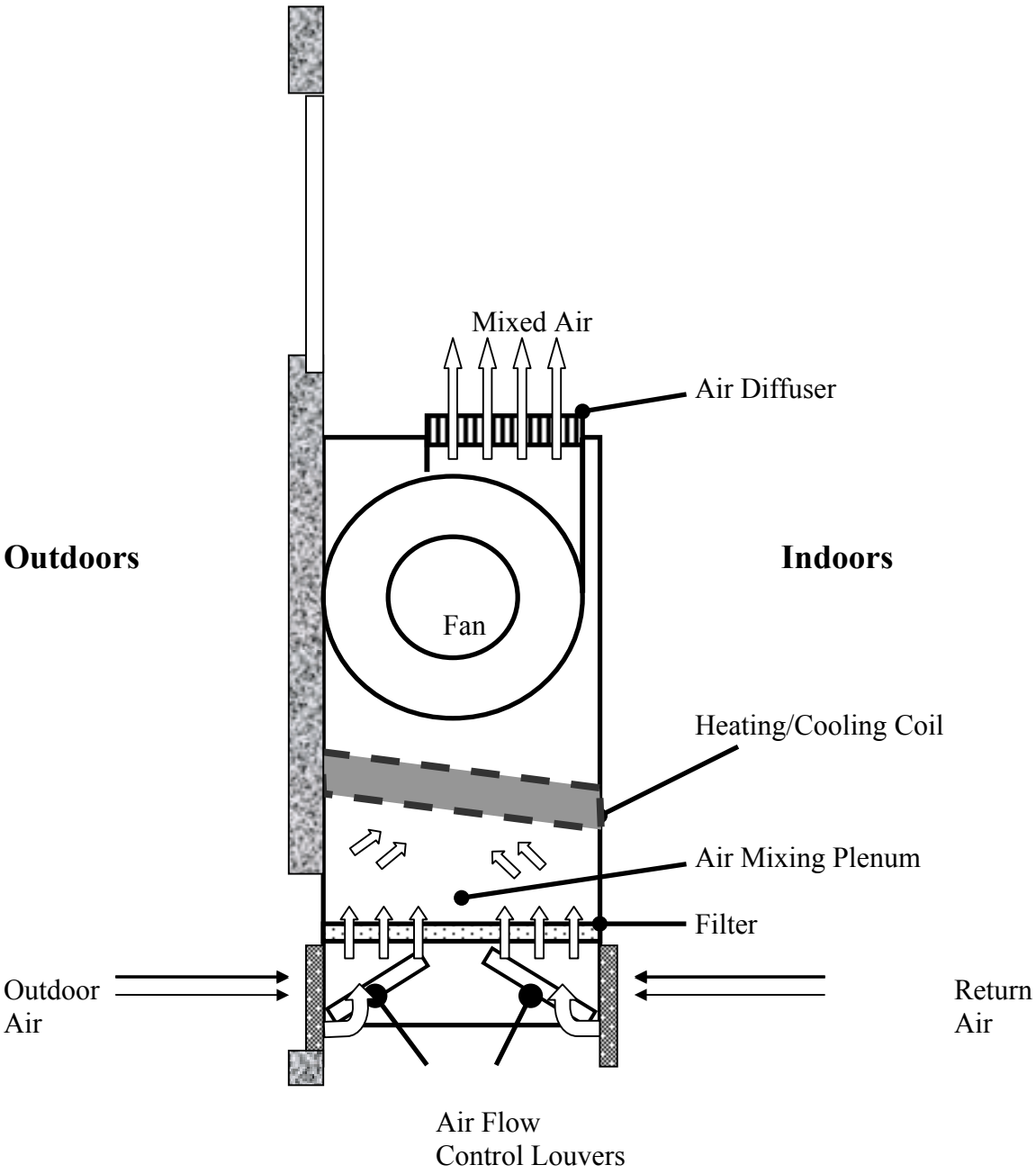
OSHA. 1997. Limits for Air Contaminants. Occupational Safety and Health Administration. Code of Federal Regulations. 29 C.F.R 1910.1000 Table Z-1-A.

Sanford. 1999. Material Safety Data Sheet (MSDS No: 198-17). Expo® Dry Erase Markers Bullet, Chisel, and Ultra Fine Tip. Sanford Corporation. Bellwood, IL.

SBBRS. 1997. Mechanical Ventilation. State Board of Building Regulations and Standards. Code of Massachusetts Regulations. 780 CMR 1209.0

Thornburg, D. Filter Selection: a Standard Solution. *Engineering Systems* 17:6 pp. 74-80.

Figure 1 **Unit Ventilator (Univent)**



Air Flow

= Fresh Air/Return Air

= Mixed Air

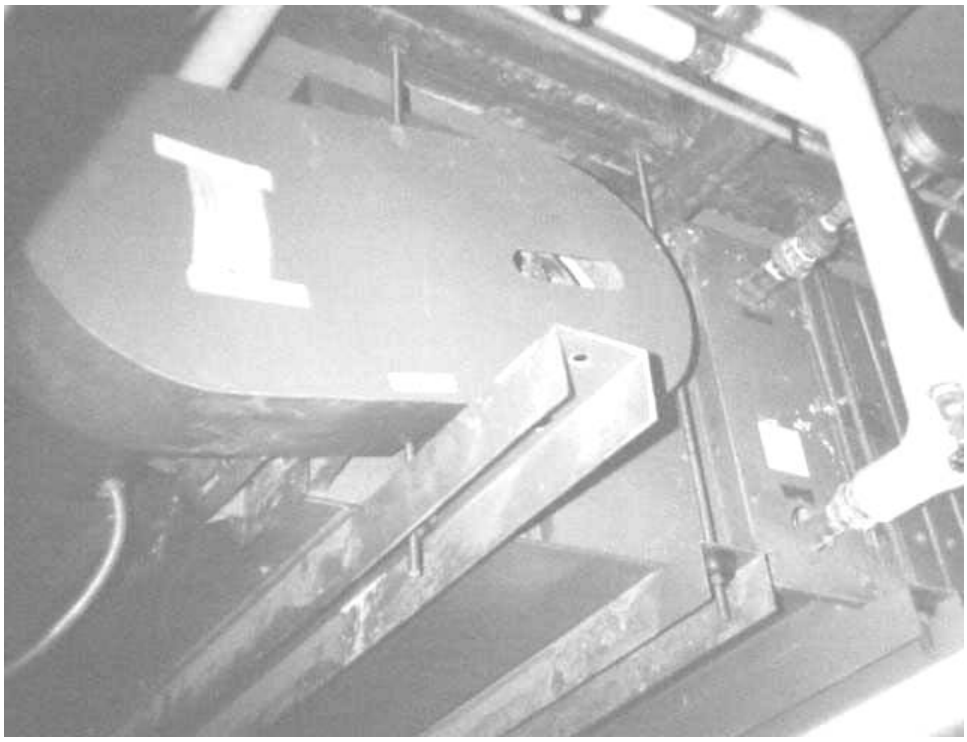
Picture 1

Classroom Univent

Picture 2

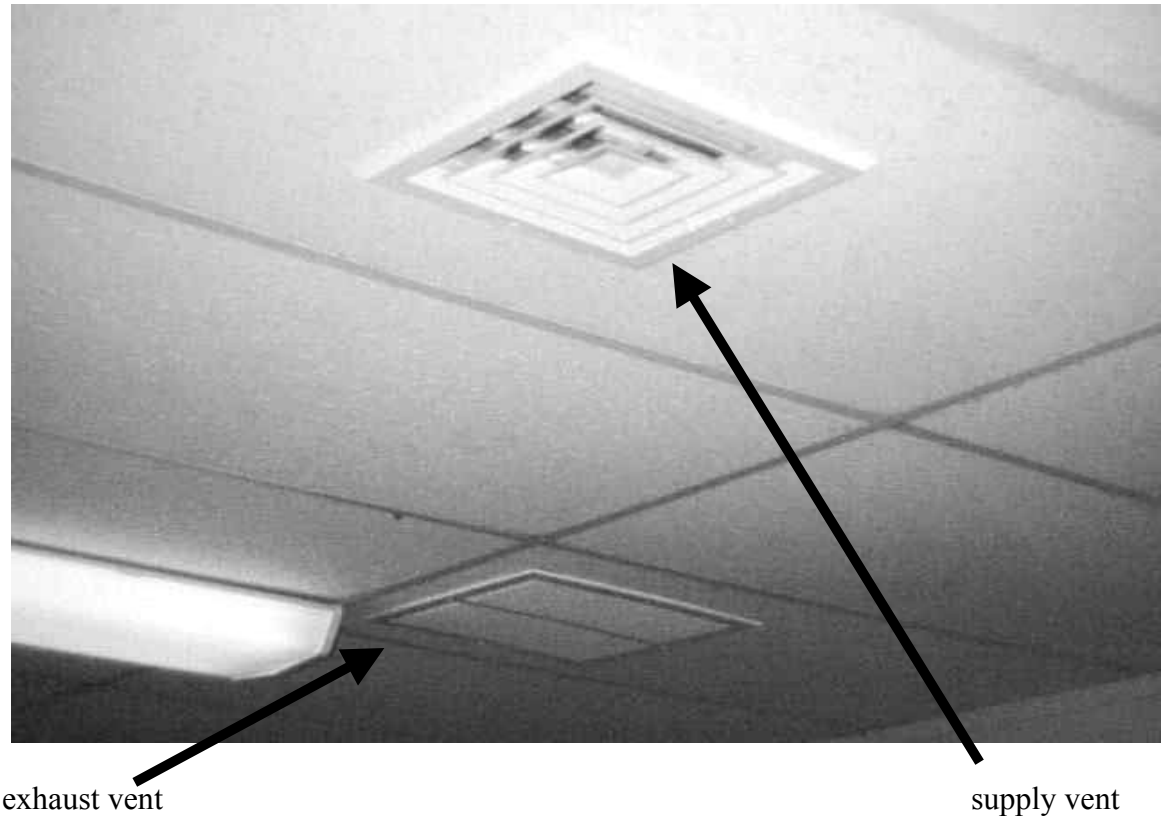
Univent Fresh Air Intake

Picture 3



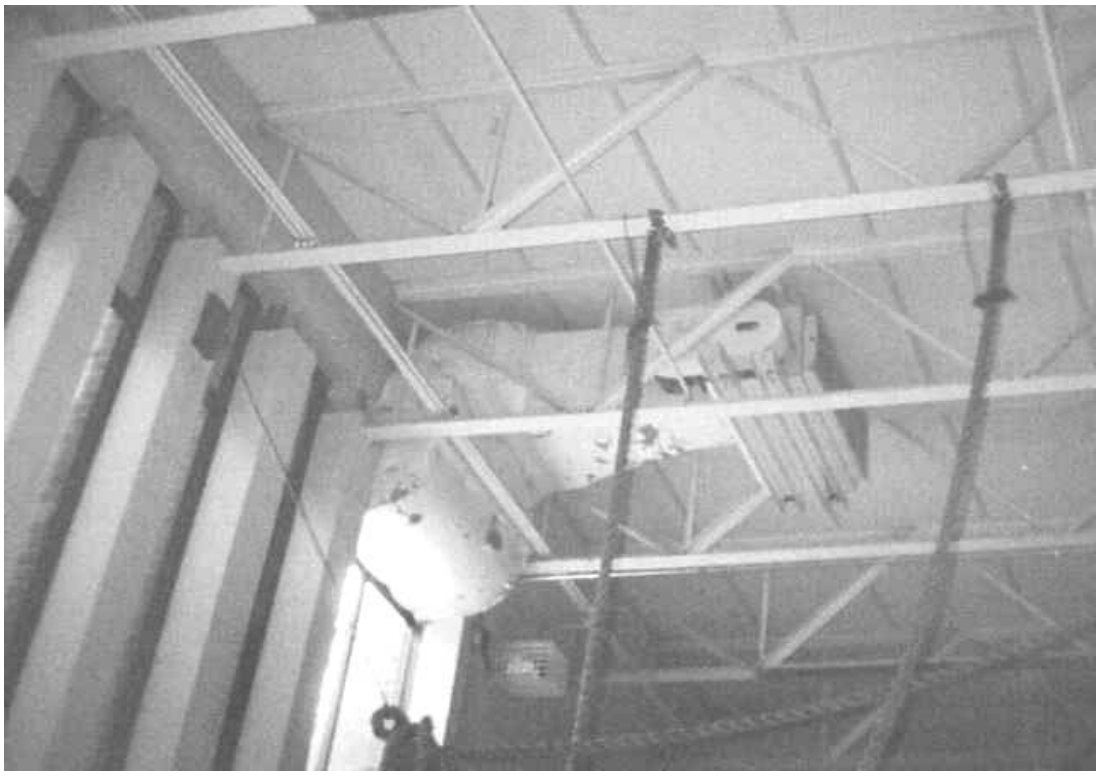
AHU in Mechanical Room Supplying the Library and Computer Room

Picture 4



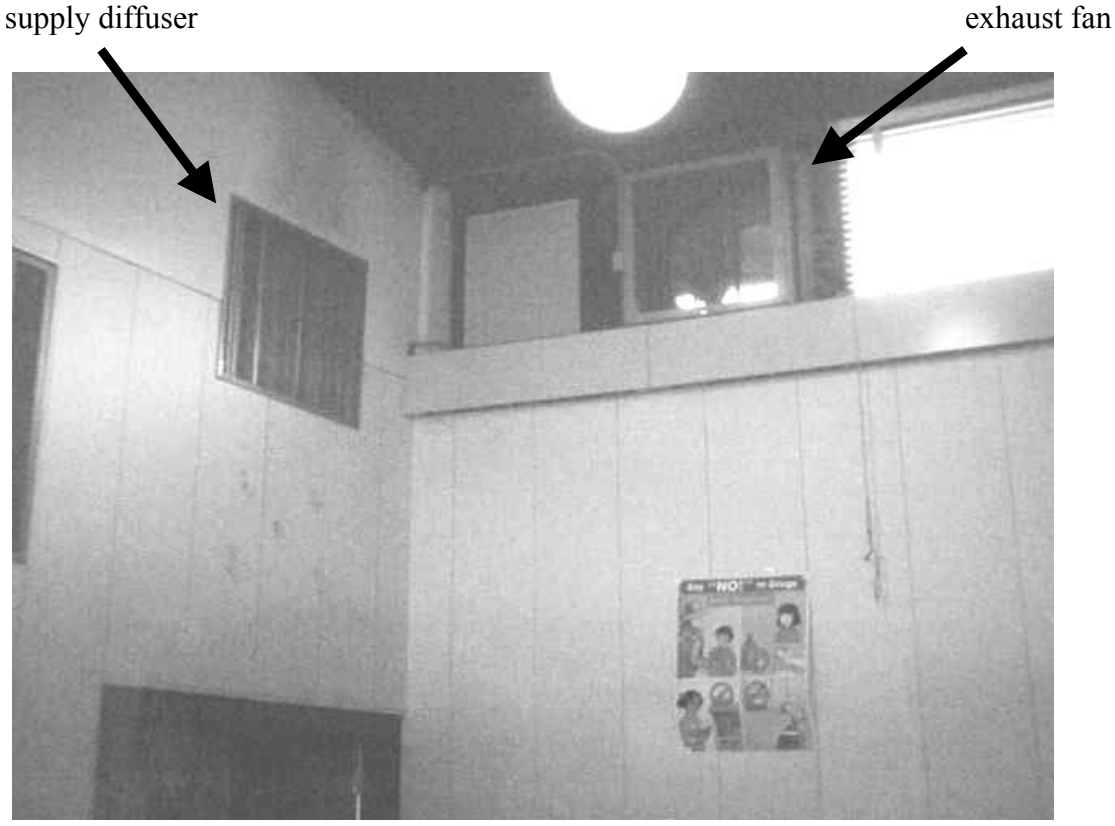
Ceiling-Mounted Supply and Exhaust Vent in Computer Room

Picture 5



One of Two Inactive AHU's in Gymnasium

Picture 6



Cafeteria Supply Diffuser and Exhaust Fan

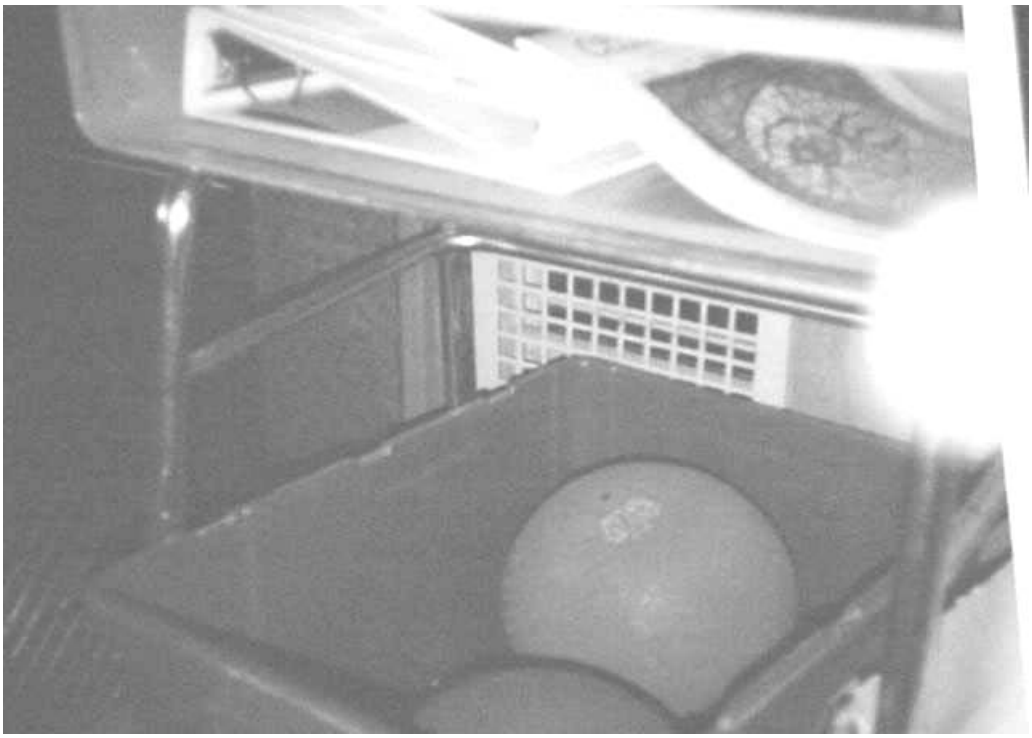
Picture 7

Example of Wall Mounted Exhaust Vent

Picture 8

Common Hallway Exhaust Vent

Picture 9

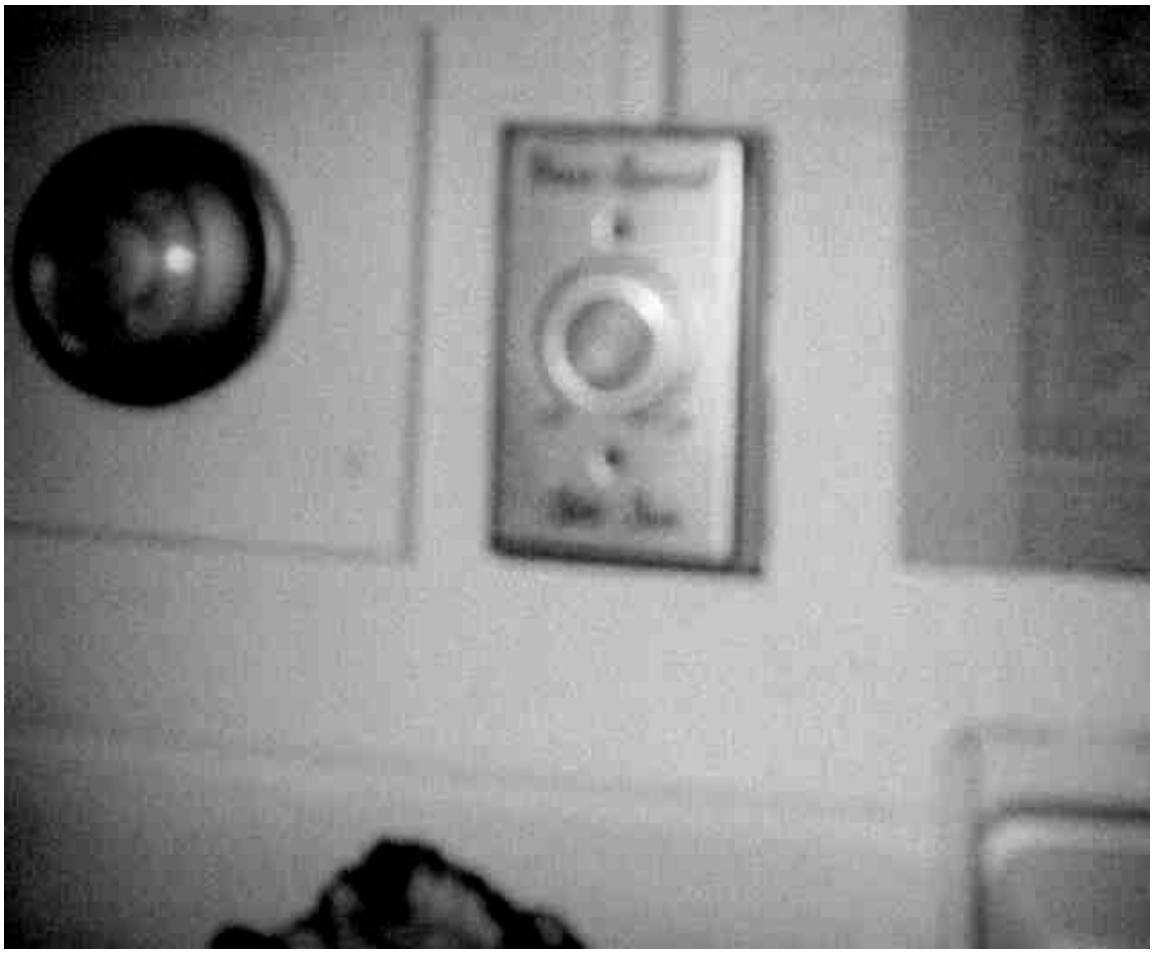


Obstructed Classroom Exhaust Vent

Picture 10

Cleaning Products in Cabinet under Sink

Picture 11



Example of Variable Speed Control for Exhaust Fan

TABLE 1

Indoor Air Test Results – Morrison Elementary School, Braintree, MA – November 6, 2000

Remarks	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Outside (Background)	324	54	47					Weather conditions: clear, sunny
109	1125	72	34	18	Yes	Yes	Yes	Air purifier, univent return blocked by desks, exhaust vent blocked by cart, spaces around countertop
111	995	72	35	0	No	No	Yes	Door open-undercut, 1 occupant gone 3 min.
108	1210	72	35	21	Yes	Yes	Yes	Door open, 4 plants, hamster, cleaning product on countertop
Men's Restroom					No	No	Yes	Door undercut
107	1520	71	36	21	Yes	Yes	Yes	Exhaust vent partially blocked by paper, door open
106	1053	71	34	19	Yes	Yes	Yes	Exhaust vent partially blocked by storage tote, spaces around sink countertop, cleaning product under sink, door open
105	823	73	34	17	Yes	Yes	Yes	Spaces around countertop
Speech Room 112	1140	70	38	6	No	Yes	No	Vent off-(noise)

*** ppm = parts per million parts of air**
CT = water-damaged ceiling tiles

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 2

Indoor Air Test Results – Morrison Elementary School, Braintree, MA – November 6, 2000

Remarks	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
103	1278	73	38	20	Yes	Yes	Yes	Door open, cleaning product under sink, 8 CT near window, leak reportedly fixed
Gym	717	70	36	0	Yes	Yes	Yes	
Gym-Instructor's Office	752	71	36	1	No	No	No	
Cafeteria	1025	75	39	~180	No	Yes	Yes	Ceiling fans, exhaust close to supply, vent off-(noise)
209	574	74	29	0	Yes	Yes	Yes	Occupants gone ~30 min., cleaning product under sink, chalk dust, door open
208	783	72	30	20	Yes	Yes	Yes	Exhaust vent obstructed, univent obstructed by tables/chairs, water damage around sink, window open
212	562	74	27	11	Yes	Yes	Yes	Window open
211	557	72	28	4	Yes	Yes	Yes	Window open
210	1136	72	32	21	Yes	Yes	Yes	Ceiling fans

*** ppm = parts per million parts of air**
CT = water-damaged ceiling tiles

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
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	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 3

Indoor Air Test Results – Morrison Elementary School, Braintree, MA – November 6, 2000

Remarks	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Media Center	752	72	32	0	No	Yes	Yes	
Music Room	1050	73	34	0	Yes	No	No	
102	1434	72	36	35	Yes	Yes	Yes	Classroom double-occupied
101	818	72	33	19	Yes	Yes	Yes	Door open, cleaning product on countertop, exhaust vent blocked by desk
Gym	897	71	36	22	Yes	Yes	Yes	Occupied, vent off
Clinic	930	73	38	2	No	No	No	3 CT
207	893	69	32	24	Yes	Yes	Yes	Window and door open, snakes/lizard/turtles-in tub-not enclosed, aquariums, frogs, live crickets in open container, taxidermy animals
219	933	71	35	1	Yes	Yes	Yes	1 CT
206	1320	72	36	25	Yes	Yes	Yes	Exhaust-weak, water damage/spaces around sink

*** ppm = parts per million parts of air**
CT = water-damaged ceiling tiles

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 4

Indoor Air Test Results – Morrison Elementary School, Braintree, MA – November 6, 2000

Remarks	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
205	586	72	31	0	Yes	Yes	Yes	Exhaust weak
Computer Room	1137	75	33	~15	No	Yes	Yes	~25 computers, no a/c, heat complaints, ceiling fans
202	661	74	30	0	Yes	Yes	Yes	Door open, exhaust vent blocked, cleaning product under sink
201	810	80	32	3	Yes	Yes	Yes	Exhaust vent partially blocked, chalk dust, temperature complaints-usually cold

*** ppm = parts per million parts of air**
CT = water-damaged ceiling tiles

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

Attachment

Braintree Public Schools

Univent Maintenance Log

Date Serviced by

Service means: *Filter Change * Motor and Bearing Oiled * Unit Vacuumed Out

Braintree Public Schools

Univent Maintenance Log

Date Serviced by

Service means: *Filter Change * Motor and Bearing Oiled * Unit Vacuumed Out

Braintree Public Schools

Univent Maintenance Log

Date Serviced by

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